U.S. Department of Agriculture Agricultural Research Service
June 1982

Agricultural Research

As the Department of Agriculture's "in-house" research unit, the Agricultural Research Service must lead the national agricultural research effort. We have been charged by the Secretary of Agriculture and the Office of Management and Budget to place highest priority on research areas of high risk and high potential, and we are to stress areas that cannot or will not be addressed by industry or state experiment stations.

ARS basic, applied, and developmental research covers many disciplines, which, for the sake of planning, are divided into five broad areas: soil, water, and air sciences; livestock and veterinary sciences; plant sciences; postharvest science and technology; and human nutrition research. Within these divisions, our goals require experts from various disciplines working cooperatively.

Through **soil, water, and air** research, we hope to improve management of natural resources. Better soil and water management, irrigation, and conservation practices are needed. We must protect natural resources from pollutants, minimize agricultural pollution, and determine the relationship of soil and water to plant, animal, and human nutrition.

Thus far, most research on soil erosion has shown how and why erosion occurs. But controlling the terrible losses of this nonrenewable resource will require more information on how soil and nutrients are lost through erosion. In addition, we need to know more about how plants tap water sources. Then, breeders may be able to develop plants with root systems that take up water more slowly.

Livestock and veterinary sciences research will be directed at helping the livestock industry produce healthy animals and safe, high-quality animal products more efficiently. Scientists are combining and integrating various techniques for improving animal reproduction. They are working on vaccine production through genetic engineering and on genetic and other ways to increase protein production, to speed progress in breeding programs, and to determine animal responses to diseases and parasites. The search continues for creative control of insects that affect man and animals. In addition, we are attempting to find how ruminants can use forages better and how environmental and nutritional stress can be reduced to increase livestock productivity and reduce disease.

Crop sciences research is directed at both crop production and crop protection. In *crop production,* a significant long-term goal is finding ways to avoid those famous "plateaus" in productivity for three major export crops—soybeans, corn, and wheat. Basic research in molecular biology, genetics, and biochemistry of soybeans will be especially important. In genetic engineering, we hope to introduce nitrogen-fixing genes into certain cereal grains, to increase the photosynthetic efficiency of plants, and to increase crop resistance to diseases, herbicides, temperature extremes, drought, and soil salinity.

Crop protection research will focus on biological and nonpesticide chemical methods for controlling or eliminating pests (for example, releasing natural enemies of pests and using baited sprays and mating confusion). We hope to isolate, develop, and use various pest body odors to increase the effectiveness of their natural enemies. Genetic manipulation also may improve biological control methods.

The current **postharvest science and technology** program is aimed at making agricultural products as nutritious, safe, and inexpensive as possible. Cutting losses of food in marketing channels by half, for example, could increase our food supply by 10 to 15 percent. And those same marketing channels are prime targets for energy conservation.

Research will emphasize quarantine treatments to destroy fruit and vegetable pests. Results of the search for alternatives to nitrite in food processing look very promising. ARS scientists are working on irradiation techniques which could revolutionize the entire food processing, transport, and marketing industry. Better and faster techniques are needed to monitor toxic and drug residues in meat and poultry, and the safety of grain inspectors and grain workers must be ensured.

ARS is responsible for the major USDA program in **human nutrition** research. This research is carefully coordinated with nutrition research in Extension Service, Food and Nutrition Service, and Cooperative State Research Service. Studies in progress concern the nutrient content of foods, biological processes that influence nutrient availability, and the interactions among nutrients and other dietary components, such as fiber. New and increasingly sophisticated techniques and instrumentation also are being developed as an integral part of these studies.

As research plans are made and strategies mapped, we are constantly aware that ARS is not an independent research organization. We are an important part of a total agricultural research system, which includes our colleagues in the state and private universities, industry, and other research organizations, and we will address the ARS mission within that system.

Terry B. Kinney, Jr.
Administrator, ARS

Contents

Agricultural Research
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Cover: Experimental sorghum destined for genetic engineering studies in Gainesville, Fla. Researchers there, and collaborators at state institutions, are working with plasmids—tiny bits of genetic material—in mitochondria of sorghum and corn. The newly-discovered plasmids may lead to hybrids with more desirable genetic traits. Article begins on page 8. (PN-6853)

Impatiens—a Touch of the Tropics

Plant geneticist Toru Arisumi maintains one of the best collections of impatiens species and hybrids in the world at the ARS Agricultural Research Center in Beltsville, Md. The stars of this floral extravaganza are the New Guinea-Indonesian varieties with their giant or unusually shaped flowers ranging in color from bright orange, yellow, and vermillion to soft shades of pink, salmon, and lavender. Accentuating this rainbow of colors, many of the varieties have leaves variegated with white, yellow, or pale pink.

Arisumi has sent cuttings and seeds from his collection, including hybrids he has developed, to breeders and scientists across the country. Much of that germplasm has been incorporated into the new varieties of impatiens on the market today.

The bedding plant industry has grown five-fold over the last decade. Impatiens now rank third in annual sales in the United States, according to a recent Census Bureau report. Although impatiens still lag far behind petunias and marigolds, they are rapidly gaining on these two favorites. Last year, the growers' association Bedding Plants, Inc., named impatiens its best seller after a 1980 survey showed that more of its members were putting their "seed money" into impatiens than any other bedding plant.

The reasons for this popularity are several. Impatiens bloom continuously during the warm weather, contrasting colorful flowers against dense foliage that remains compact throughout the summer. Unlike petunias, impatiens thrive in the shade. In fact, they cannot tolerate full sun, high heat or lack of water. They keep themselves well-groomed by sloughing off dead flowers, leaves, and branches, and they tolerate air pollution as well as marigolds do. The most common market varieties are hybrids of the African species, *Impatiens sultani,* or the Indian species, *Impatiens balsamina*.

Plant geneticist Toru Arisumi (foreground) and research technician Kenneth Lehnert look for favorable genetic traits in New Guinea impatiens hybrids. (1281W1529-26)

As long as gardeners appreciate these esthetic qualities, growers will reap the profit. According to the Census Bureau's 10-year report on agriculture, the bedding plant industry grossed $285.5 million in 1979 from floral and vegetable crops. Impatiens captured 6.2 percent of this market—$17.6 million in wholesale and retail sales. And that was 3 years ago. Impatiens have made their biggest gains since then.

Impatiens (the name of the genus) were first discovered in east Africa by an Englishman, Sir J. D. Hooker, around the turn of the century. They were grown in conservatories in England and continental Europe, but were not introduced to the public until somewhat later, probably because their seeds were hard to find, wrote H. F. Winters in a 1973 *American Horticulturist* article. The ripe seed pods explode when touched, scattering their contents in all directions. Hence their alias, "touch-me-nots."

In 1970, Winters and J. J. Higgins collected many new species of impatiens during an expedition to New Guinea for ornamental plants. The two men, both with ARS at the time, sent back 25 species from the highlands of Australian New Guinea and one species from the Indonesian island of Java. Through their efforts, two species from Celebes, Indonesia, arrived later.

After nearly 2 years in quarantine, USDA's Plant Introduction Station (Glenn Dale, Maryland) sent cuttings from these plants to research institutions, commercial growers, amateur breeders, and to the Longwood Gardens in Kennett Square, Pennsylvania, which cosponsored the expedition with USDA.

The New Guinea-Indonesian collection provided a wealth of new and unusual plant material for breeders. However, mature plants had a tendency to become tall and spindly, and lost lower foliage as they aged. Most bloomed for relatively short periods compared to free-flowering varieties listed in catalogs, Arisumi wrote in a 1976 *HortScience* article. "None of the original collection was considered to be competitive with the [*Impatiens*] *sultani* types for freedom of blooming or performance in the garden." Futhermore, they were poor seed producers, he said, explaining that most growers propagate impatiens from seed rather than from cuttings.

Arisumi overcame some of these drawbacks by hybridizing. In the mid-1970's, he introduced several new varieties with names like Aloha, Pee Gee, Pink Cascade, and Sweet Sue. Although they were continuous bloomers and more compact than their forebears, most had to be propagated by cuttings.

Since 1972, Arisumi has cross- and self-pollinated thousands of impatiens species and hybrids, including the African and Indian types, to study their breeding behavior. He can frequently be found peering through the microscope at their root cells to study the number and kinds of chromosomes.

The crossing studies produced a picture of impatiens' probable evolutionary history; it also exposed problems that have to be solved before a marriage between the New Guinea impatiens and their distant relatives from Africa and India can bear progeny.

Crosses between the New Guinea species produced hybrids whose flowers contained fertile pollen and eggs. With one exception, these species have 32 chromosomes. A hybrid exhibiting desirable traits has to be backcrossed with parents over several generations before it will produce uniform progeny. Not only does the process consume time and space, says Arisumi; it is also difficult, because some backcrosses don't take and others produce weak progeny.

This was not the case in crosses between New Guinea and Java or Celebes, or between Java and Celebes. Hybrids had sterile pollen and eggs. The Indonesian species have different numbers of chromosomes: Java has 16, Celebes 8. Because these chromosomes don't "match" (they aren't homologous) among themselves or with New Guinea chromosomes, they don't divide in an orderly fashion when forming pollen or eggs, he explained.

Arisumi treated the leaf axils of seedlings with the long-used chemical, colchicine, to double the chromosomes. New shoots from the treated axils contained paired chromosomes, and their flowers produced fertile pollen and eggs. Moreover, because the chromosome pairs were identical, the hybrids produced uniform progeny when self-pollinated.

In this way 'Sweet Sue' was born. Released to florists and nurserymen in 1976, this everblooming beauty contrasted large bright orange flowers against variegated leaves of green with yellow centers. Its parents were a New Guinea hybrid and a Celebes variety, 'Tangerine.' 'Sweet Sue' is a good seed setter, Arisumi said, and the first introduction from the New Guinea-Indonesian collection to breed true to seed.

Crosses between the New Guinea-Indonesian group and the African or Indian species failed to produce seed even when the species had the same number of chromosomes. The fertilized eggs, or embryos, died before they matured into seed. Embryos from crosses between African and Indian types also died, prompting Arisumi to conclude that, from an evolutionary standpoint, the African and Indian species he tested are probably much older than the New Guinea-Indonesian species. "They are quite different from one another and are very difficult to cross. By contrast, the New Guinea-Indonesian species have many similar traits and cross easily among themselves regardless of differences in chromosome numbers."

He also speculated that the New Guinea and Java types could be evolutionary spinoffs of Celebes or other closely related species because New Guinea and Java chromosomes appear more similar to each other than to the chromosomes of Celebes.

Arisumi wants to combine the best qualities of the New Guinea impatiens and the commercial best sellers. To cross this barrier, he transplants embryos to a culture medium before they die.

Horticulturists have been removing embryos from plants and growing them in nutrient concoctions since the turn of the century, he said. But because the embryos in these incompatible crosses stay alive only 1 or 2 weeks,

they are too small to excise and too underdeveloped to survive on their own. So Arisumi cultures the ovule—the immature seed which contains the developing embryo.

So far Arisumi hasn't produced many seedlings—only a fraction of 1 percent survive, he said. Although he is the only person attempting to rescue these botanical miscarriages, he is optimistic that he can produce more seedlings with time.

Meanwhile, he proposes another way to make the New Guinea group compatible with Indian species, which account for nearly half of the 500 known impatiens species. By crossing the New Guinea types with varieties from Indonesia and from islands around tropical India, breeders might be able to bridge the gap, he says. Along the way, they may discover genes for tolerance to heat and drought that will enhance impatiens in the garden. They may also discover genes for tolerance to low light and humidity that will allow impatiens to thrive indoors.

If this should happen, growers and flower lovers will have the best of all possible worlds. Watch out, petunias!

Toru Arisumi is located at the Florist and Nursery Crops Laboratory, Bldg. 004, Beltsville Agricultural Research Center-West, Beltsville, MD 20705.—(By Judy McBride, Beltsville, Md.) ■

Above: Arisumi checks ovule cultures for signs of germination. By culturing immature ovules from parents too distantly related to produce viable seeds, he saves some embryos that would otherwise abort. (1281W1528-14)

Top right: Only one-tenth of one percent of the ovule cultures survive and grow into seedlings. These seedlings are ready for greenhouse soils. Once transplanted, very few are lost. (0382W177-4a)

Saline Water Used to Produce Biomass

Weeds are plants whose virtues have not yet been discovered, according to Ralph Waldo Emerson.

Halophytes—highly salt tolerant plants—generally have little economic value, but ARS plant geneticist Michael C. Shannon, of the U.S. Salinity Laboratory, Riverside, Calif., is studying three species of halophytes that may have some potential. He is growing the plants with water containing up to one-third the salinity of seawater. Shannon is looking for ways to use highly saline water, such as drainage water from irrigated fields, one more time before it is discarded.

"In many regions of the earth, water rather than land is the limiting resource for the increased expansion of crop production. Often ground water or agricultural drainage water is available but is too saline for use on conventional crops. By using the saline ground water or drainage water on a succession of salt tolerant crops, we not only add to crop production but find a use for water that is otherwise wasted," Shannon says.

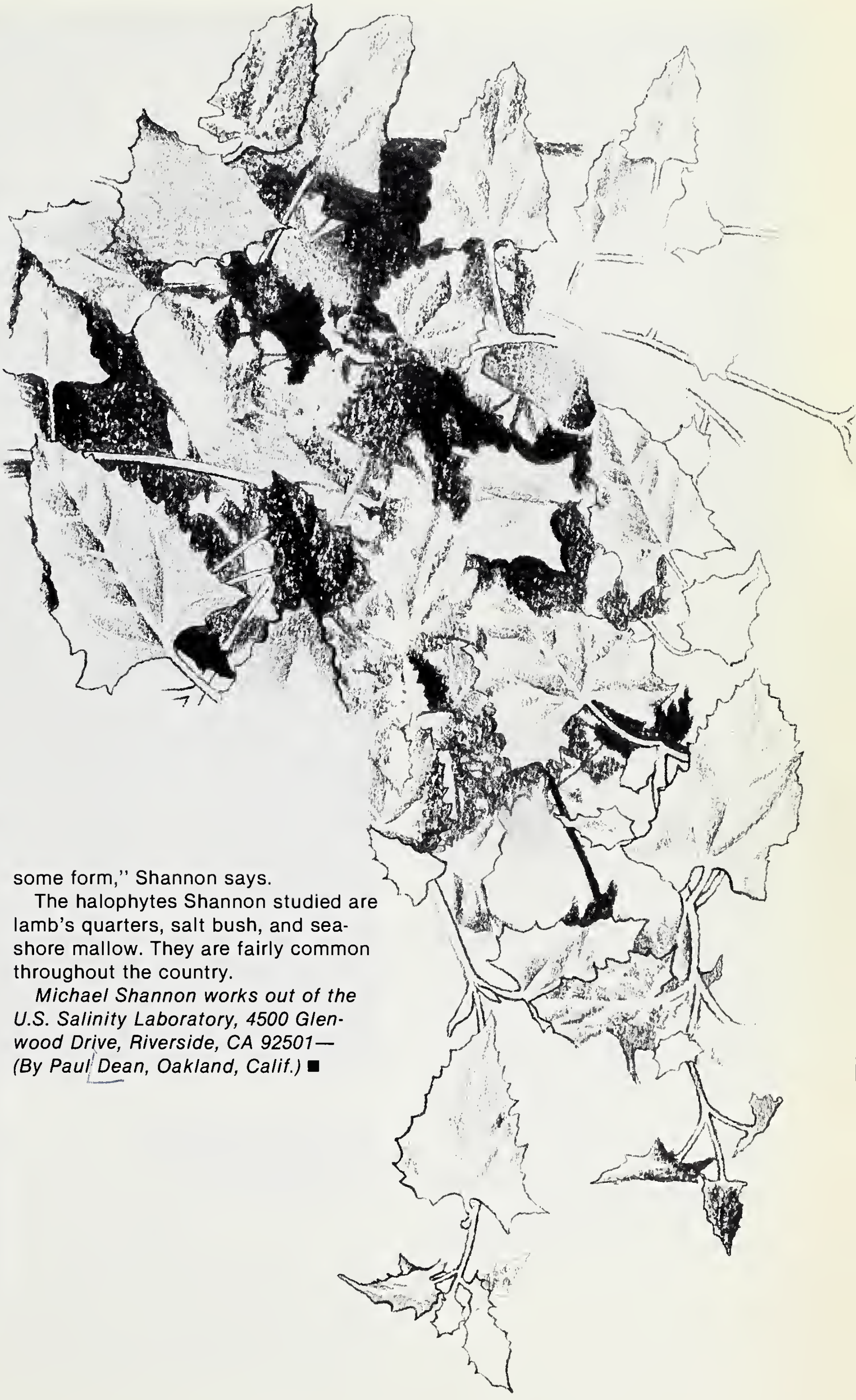
In a field study, cowpea, wheat, and barley were compared to three species of halophytes using waters of five different salinities from nearly zero to about 12,000 parts per million (ppm). Cowpea is fairly sensitive to salt, wheat is somewhat tolerant, and barley is more tolerant.

Yields of the three commercial crops were reduced at salinities of about 3,000 ppm, but the halophytes had greater seed and vegetative yields at salinities as high as 10,000 ppm. Even higher salinities reduced yields slightly, but not so much that they were significantly less than yields from the nonsaline treatment.

"More effort needs to be made in developing the economic potential of halophytes—perhaps, for instance, using them in the production of energy in some form," Shannon says.

The halophytes Shannon studied are lamb's quarters, salt bush, and seashore mallow. They are fairly common throughout the country.

Michael Shannon works out of the U.S. Salinity Laboratory, 4500 Glenwood Drive, Riverside, CA 92501—(By Paul Dean, Oakland, Calif.) ■



Plasmids: New Key to Genetic Engineering?

When an ARS plant pathologist and a North Carolina State University geneticist explored the small energy-producing bodies called mitochondria in corn cells, they found what may be a potential gold mine of genetic information.

In the mitochondria they discovered plasmids—tiny DNA molecules—that could be used to breed plants with desirable traits such as disease resistance, increased yield, and improved seed quality.

The newly discovered plasmids may someday lead to more productive hybrids of sorghum, as well as corn, two of the world's major crops.

"We found the plasmids while we were searching for improved sources of male sterility in corn that might produce new male-sterile hybrids," says plant pathologist Daryl R. Pring, Gainesville, Fla. "Male sterility is not only extensively used by breeders to produce hybrid corn, but it is currently the only practical way to develop hybrid sorghum."

Plant breeders produce hybrid offspring by cross-pollinating different plants of the same species—such as corn—to transfer genetic traits between them. Usually the pollen, or male part of the flower, is removed by hand to guarantee male sterility. Use of the plasmid may ensure sterility and save a lot of hand work, Pring says.

The ARS-state cooperative research, which began with Pring and North Carolina State University geneticist C. S. Levings, has some elements of an adventure story—search, suspense, and discovery. But the suspense comes last in this new genetic research. The possible impact of the plasmids on higher plants, all of which contain cellular mitochondria, is almost immeasurable, and the full impact of the plasmids on future genetic engineering studies with male-sterile corn and sorghum is long range.

Just how do these new plasmids affect male sterility in corn?

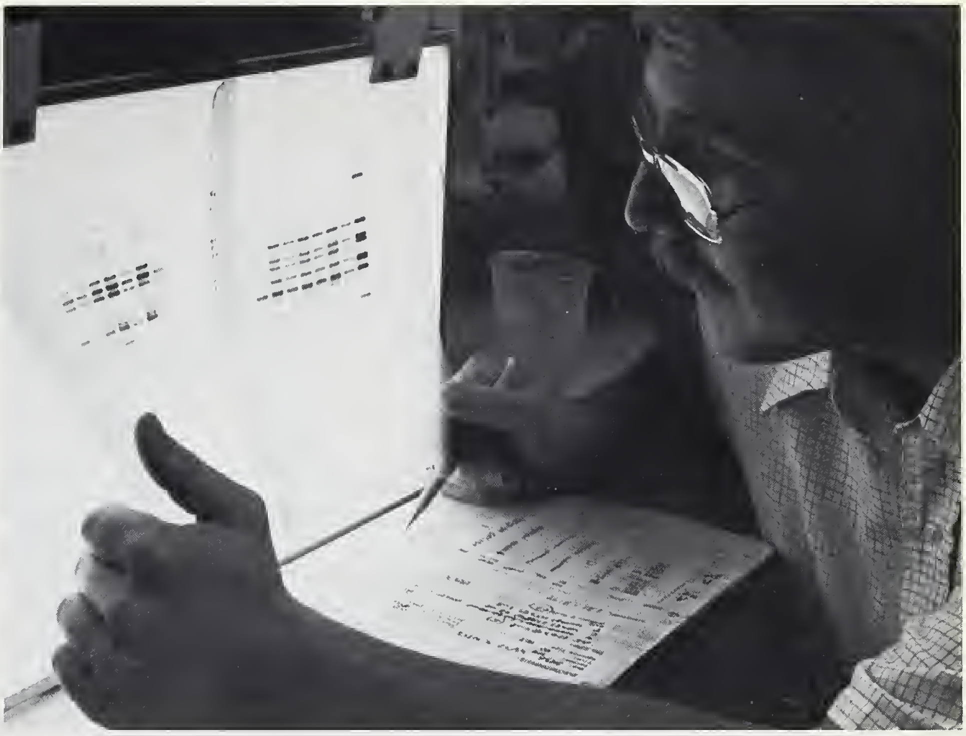
"Plant protoplasts, individual plant cells whose walls have been dissolved

Above: Flowers of experimental sorghum from African and Indian lines for DNA studies are examined by plant pathologist Daryl R. Pring and research associate Christine D. Chase. (0382X213-2)

Opposite top left: Research associate James W. McNay prepares male-sterile corn seedlings for study. He will eventually isolate the mitochondria from the cells. (0382X216-24a)

Top right: Graduate student Allan Smith examines images that form the DNA "fingerprint" of specific male-sterile lines. (0382X215-36a)

Bottom: Under ultraviolet light, Pring photographs gels containing DNA types having different molecular weights. The photos will show whether plasmid DNA is present. (0382X217-6a)



by an enzyme, can be fused to combine genetic material from different sources," says Pring. "In corn, the plant we first studied, the new plasmids might be introduced into different cytoplasms—cellular material minus the nucleus—by means of protoplasts, and the plasmids could then generate new sources for male sterility. In other words, we would manipulate the plasmids to alter the corn plant for genetically desirable traits."

One main source of sterility in corn, the T cytoplasm, results in disease susceptibility, Pring says. "Our studies are designed to eliminate that susceptibility. On the other hand, our sorghum work is preventive medicine. We want to broaden the cytoplasmic base of sorghum to avoid potential disease or insect problems."

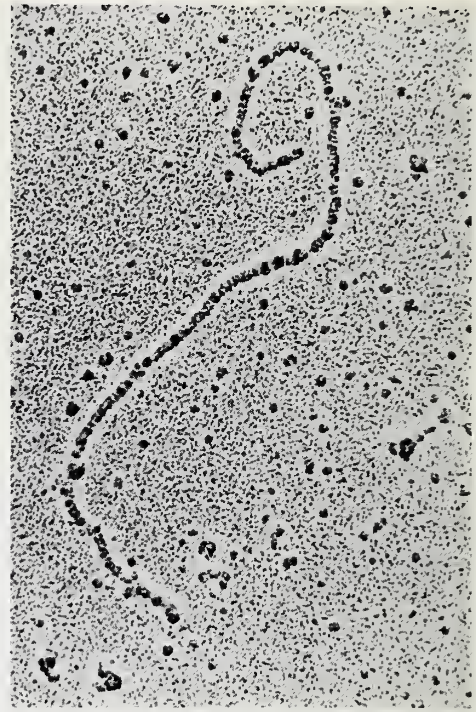
Early in the coordinated research, Pring and Levings followed their initial findings with the discovery that large DNA molecules in normal, fertile corn lines shared molecular similarity with the new plasmids.

They located "free plasmids"—independent, tiny molecular entities associated with the mitochondria—in the cytoplasm of one male-sterile mutant of corn. These plasmids may originally have come from fertile corn but were cut out during the evolutionary process, converting the plant from male-fertile to male-sterile.

Geneticists J. R. Laughnan and S. J. Gabay-Laughnan at the University of Illinois found naturally occurring mutants in corn that had lost the free plasmids. Then Pring and Levings, with the University of Illinois collaborators, found evidence that the plasmid had been integrated back into the mitochondrial genetic material, making the plant self-fertile. This indicated to the scientists that the free plasmids may be causing the male-sterile condition in corn.

In collaboration with ARS geneticist K. F. Schertz at Texas A&M, Pring and his associates also found plasmids in the mitochondria of male-sterile sorghum. Corn and sorghum plasmids share molecular similarity, suggesting a common mechanism of male sterility in these two plants.

Importantly, the new sorghum plasmids may be capable of producing



Above: Collaborating University of Illinois scientists J. R. Laughnan and S. J. Gabay-Laughnan examine the stored genetic stocks of the many parental lines and mutants they use in their study of plasmids in corn. (0482X288-12a)

Right: Electron micrograph shows a plasmid—a tiny DNA molecule—from a male-sterile sorghum line. (PN-6854)

what the scientists want: new male-sterile hybrid lines to avert disease epidemics.

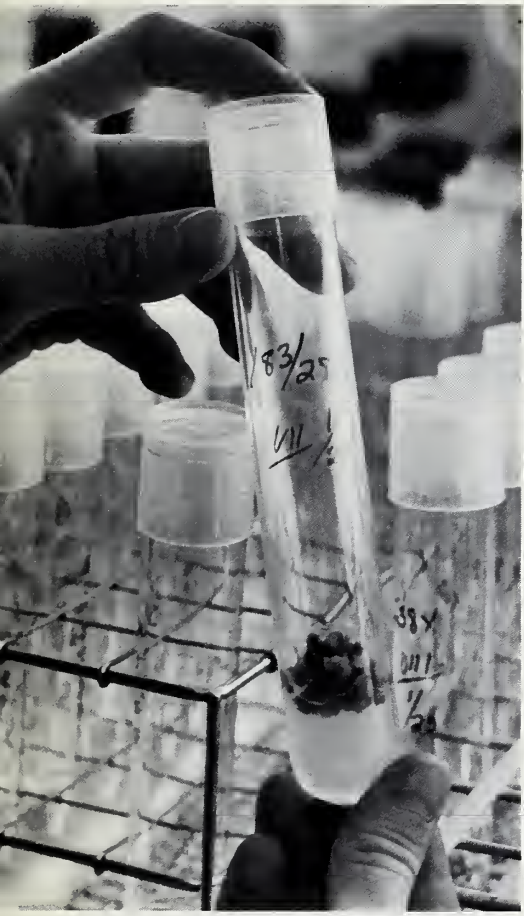
Looking to the future, Pring says that the genetic engineering potential will be realized when genes necessary for plant improvement can be isolated and inserted into the plasmids, together with a system to detect altered plants.

New technology will be important to isolate agronomically desirable genes, Pring adds. Plant protoplasts that are capable of regeneration into mature plants will be required as recipients for these genes in genetic engineering studies.

Genetic engineering technology is now successfully being applied to microorganisms and will work in higher plants, according to Pring. "I expect to see major demonstrations of the technology in higher plants before the 21st century. Researchers in Germany and Belgium have already genetically engineered tobacco plants."

Closer to home, ARS geneticist P. S. Chourey at the University of Florida says, "I have long-range interests in studying gene expression and gene regulation in corn. I analyze genes and their products at the whole plant level, as well as at the cellular level, to understand how they regulate and express certain traits, such as seed quality, during plant development. For example, these traits might include the size and appearance of the seeds, whether they are small or large, crinkled or smooth, and ultimately, whether they are good or bad seeds for our specific research purposes.

"These efforts have now been immensely aided by recent advancements in recombinant DNA and plant tissue



culture technologies. Our recent success in corn protoplast culture—regenerating new growth, or callus cells, from the growth and development of corn protoplasts—will be particularly useful in such basic studies."

Florida-Antilles Area Director Dean F. Davis finds the plasmid research relevant to world hunger.

"Demographers tell us that there are more than 4 billion people on earth. It is estimated that 400 million of those people will suffer serious malnutrition, and some will be starving by the year 2000 if very serious efforts are not made to increase capabilities for agricultural production."

Davis is referring primarily to the need for the United States to assist developing countries in achieving increased agricultural capabilities and technologies.

Certainly, agricultural research will be enhanced worldwide if productive new disease-resistant corn and sorghum hybrids became a reality.

USDA-ARS, the USDA Competitive Grants Program, and the Florida Agricultural Experiment Station supported the cooperative research, with input from state collaborators and the Plant Breeding Institute, Cambridge, England.

Daryl R. Pring and P. S. Chourey are located in the Department of Plant Pathology, Horticultural Sciences Building, University of Florida, Gainesville, FL 32611.—(By Peggy Goodin, New Orleans, La.) ■

Above left: A mass of unorganized, developing corn callus cells thrive on a growth medium. The cells can be "triggered" by varying hormone levels to produce roots, leaves, or shoots. (0382X218-20a)

Above: In the laboratory equivalent of planting, technologist Diane Z. Sharpe propagates corn cells in cultures. Some cultures are mutants that will aid studies of gene structure and function. (0382X217-25a)

Improving Carrot Flavor

Above: Geneticist Philipp W. Simon collects "flavor" samples from carrots. The samples will be analyzed for chemicals that make up flavor. (0382X251-10a)

Above right: University of Wisconsin specialist Kristin Clausen prepares a freeze-dried carrot to analyze its pigment levels. The pigments are a source of vitamin A. (0382X250-16)

Plant breeders can improve both flavor and nutritional value of carrots while improving agronomic qualities. The potential for improving flavor genetically may be especially great for carrots grown under conditions like those of Florida and Wisconsin.

ARS plant geneticist Philipp W. Simon and coworkers at the University of Wisconsin-Madison conducted experiments with carrot breeding lines and hybrids grown in various soils and simulated climatic conditions. A taste panel evaluated the flavor of the carrots grown, and nutritive and flavor components were analyzed in the laboratory.

"We found that differences in flavor components were more attributable to genetics than to climatic conditions," says Simon. "The genetic influences were greater under conditions of Tallahassee, Fla., and Palmyra, Wis., than under those of El Centro, Calif."

To simulate climatic conditions, Simon and his colleagues used rooms in the biotron—a controlled-environment building on the University of Wisconsin-Madison campus. They also grew carrots under natural Wisconsin conditions.

Flavor qualities of carrots grown under simulated and natural Wisconsin conditions were similar. Further studies could be designed to measure the individual effects of temperature, relative humidity, day length, and light intensity.

Climate late in the growing season may be more responsible than early climate for developing harsh flavors. The researchers found that carrots grown in the Florida climate for 40

days and then in the California climate the following 60 days had flavors no different from those grown in the California climate for the whole season. But carrots grown in the California climate for 40 days and then in the Florida climate the following 60 days had harsher flavors than California carrots and milder flavors than Florida carrots.

Carrots grown on muck soils from central Florida and southern Wisconsin were generally not quite so sweet or mild in flavor as carrots grown on sandy clay from the Imperial Valley of California. But because variation in expression of genetic traits was greater under Florida- and Wisconsin-like climatic conditions than under California conditions, the potential for improving flavor of carrots grown in these states seems greater.

Simon observes that sugar levels in carrots are strongly controlled by genetics.

Levels of total sugars in carrots influenced the taste panel's preferences, but levels of terpenoids that impart harsh flavors influenced them more. The terpenoid levels, like sugar levels, were influenced more by genetics than by environment, Simon says.

Acidic Wisconsin muck soil produced carrots with the highest level of the pigment associated with carotenoid or pro-vitamin A levels. Carotenoid levels did not influence preferences by the taste panel. This is encouraging, Simon says, because it suggests that carrot flavor can be improved without lessening nutritional value.

Carrots that the scientists used for the study included the inbreds B493 and B10138 and a first-generation hybrid of the two inbreds, which resembled the milder-flavored B10138 in flavor characteristics.

Philipp Simon is located at the Dept. of Agronomy, University of Wisconsin, Madison, WI 53706.—(By Ben Hardin, Peoria, Ill.) ■

Spray the Grass, Not the Corn

By keeping an eye on grassy areas around corn fields, and treating them when adult European corn borers (moths) become active, farmers can reduce both corn losses and costs of borer control.

In 3 years of tests, ARS research entomologist William B. Showers found that applying carbaryl insecticides to foxtail and other weeds in conservation lanes and along borders of corn fields significantly reduced corn borer damage. Showers, stationed at USDA's Corn Insects Research Laboratory on the Iowa State University Research Farm, Ankeny, Iowa, applied insecticide when the corn borer moths began to fly into the grassy areas to mate.

Following treatment of grassy areas, the average number of egg masses per corn stalk was 0.2. Without treatment of grassy areas, corn averaged 3.3 egg masses per stalk. Corn grain yields were 9 percent higher in treated areas and counts of borer-produced stalk cavities were 65 percent less, Showers adds.

"In order to control any insect, you have to study its life cycle and look for weaknesses," he says. "In this case we found that when the female moth emerges in the corn field in midsummer, the product of the spring generation, she seeks out a grassy area to rest and find a mate, sometimes as far as 100 yards from the corn field. Then she returns to the corn field to lay her now-fertile eggs."

The male moth emerges in the corn field and flies to a grassy mating site where he remains until the female population is dispersed. Then he moves on to another grassy area, Showers says.

Showers found that he needed to take borer samples at 20 or more locations in dense grass sites to accumulate enough data to predict how serious the corn borer problem would be in a corn field. He used a net that covers about 1 square yard and encompasses the space from a height of 3 feet to ground level. He can predict the number of egg masses per corn stalk from the number of female moths he catches in each sample.

Four female moths in an average sample equal one egg mass per corn stalk nearby. Seven females per sample equal two egg masses per stalk. Ten moths equal three egg masses.

Presently, Showers and Iowa State University graduate student Thomas W. Sappington are comparing the drop-net system with a simpler technique—walking through the grass and counting the number of moths that flush within 34 feet.

"If you are willing to spend some time checking on how many female corn borer moths are in the grassy areas around your corn fields, you can avoid treating unnecessarily, or at least treating the whole corn acreage," Showers said. "Treating the grassy areas up to 150 feet surrounding the corn fields will greatly reduce the acreage you must cover."

If you apply an insecticide at the right time to kill most of the females before they can return to the corn field to lay their eggs, control should be very effective. Two applications will probably be needed. The first treatment should be made when, after taking a minimum of 20 samples, you find an average of 4 females in a square yard of grassy area, Showers said. The second treatment should be made about 8 days later.

"Another option, or gamble," Showers says, "is to do the best you can with cultural practices, such as chopping up the corn residues, and hope that nature will do her part to keep the borer population from reaching economically damaging levels. Fortunately, the corn borer has a lot of other enemies besides us. They suffer from predacious birds, viruses, parasites, and so on, just like the rest of Earth's creatures. However, the weather will save us from the corn borer more often than not."

Another ARS entomologist, Edwin C. Berry, worked on the study, as did L. Von Kaster, one of Showers' graduate students at Iowa State University.

William B. Showers, Jr., is located at the Corn Insects Research Laboratory, Ankeny Research Farm, RR#3 Box 45B, Ankeny, IA 50021.—(By Ray Pierce, Peoria, Ill.) ■

245

Protein—Now from Grass and Clover

E1 J.

Forages such as this Coastal bermudagrass can yield high quality vegetable protein for human and animal diets alike. (1073X1609-22)

Proteins suitable as a food supplement for humans can now be removed from grasses and clover—commonly known as forages in the agricultural community.

In the last few years, interest in protein from leaves has increased since forages can yield more usable dry matter and protein per acre than any other crop.

"Because forages are so plentiful, we decided to check them out to see what we could get," says John J. Evans, an ARS research chemist with the Richard B. Russell Agricultural Research Center, Athens, Ga. He used Coastal bermudagrass and white clover in his tests.

Previously, only green proteins could be easily removed from forages—usable only in animal feeds. Now, with adjustments in the medium's pH level—acidity or alkalinity—during the extraction process, Evans succeeded in getting white protein from grass and clover cells. "This protein can be used as a food additive," says Evans, "incorporated into cereals, perhaps, or anything low in protein."

The proteins were extracted using water and heat. Once extracted, they look like fluffy green or white powders. The green protein can be used in feed for animals—chiefly poultry, according to Evans—and the white protein is suitable for humans.

Earlier studies used the natural pH of the plant material or a slightly higher level. But after trying many different pH levels, Evans discovered the optimal level. In Coastal bermudagrass, 12 percent of the total protein was extracted at pH 7, the natural pH of pure water. Half the protein was white and half green. Similarly, in white clover, 21 percent of the total protein was extracted at pH 8 (very slightly alkaline); 40 percent was white and 60 percent was green.

The green protein was then separated out in a centrifuge. After that, the white protein was precipitated from the remaining liquid by heat. Not only were the proteins of high quality, but also the residue contained enough protein that it could be used as an excellent feed for ruminants.

Evans says, "pH is important to consider when extracting and fractionating plant material, especially if a forage is processed to obtain both green and white proteins. Then the selection of the proper pH is essential." A relatively inexpensive adjustment in pH will considerably increase protein production.

"It's still early," Evans says, "and the research is preliminary. But we now know how much and in what form the proteins can be extracted from these two forages."

Further tests should determine possible and practical uses for the extracted proteins.

John J. Evans is with the Field Crops Research Unit located at the Richard B. Russell Agricultural Research Center, P.O. Box 5677, Athens, GA 30613.—(By Bennett Carriere, New Orleans, La.) ■

100

The Birds and the Psyllas

Winter birds frequent orchards in the northwestern United States, and some do feed on overwintering pear psylla, but they don't eat enough insects to improve psylla control very much.

"Birds are frequently disregarded as predators in agricultural and horticultural insect control programs because it is difficult to evaluate their effectiveness," says ARS entomologist Robert E. Fye, Yakima, Wash. However, to see just what role birds do or could play in controlling insect pests of pear orchards, Fye spent about 3 months surveying winter birds in the Yakima Valley in central Washington.

Fye chose to study the effect of birds on pear psylla because the tiny, aphid-like insect, whose honeydew causes browning or russeting of fruit, threatens the existence of the fresh-fruit pear industry in the Northwest. Control with insecticides is precarious, and some biological control will apparently be necessary (see *Agricultural Research,* Sept. 1980, p. 11).

Of all the birds Fye observed, he says, "Only the Oregon junco occurred in sufficient numbers to have measurable impact on psylla populations."

From his findings, Fye estimates that flocks of 50 to 150 juncos could remove from orchard duff 23 to 70 thousand psylla females with a potential production of 7 to 23 million eggs.

"This estimate appears to be a sizable reduction but may be relatively insignificant due to the small segment of the psylla population overwintering in orchard duff," he says. Still, the potential is definitely there. Meanwhile, Fye is continuing his efforts to develop other organisms as a means of pear psylla control.

Robert E. Fye is located at 3706 West Nob Hill Blvd., Yakima, WA 98902.—(By Lynn Yarris, Oakland, Calif.) ■

Controlling Wheat Take-All Disease

Coating wheat seed with select strains of bacteria before planting may well spell biological doom for take-all, one of the worst root diseases of wheat in the world.

ARS plant pathologists R. James Cook and David Weller, Pullman, Wash., have found that cultures of short, rod-shaped bacteria, called pseudomonads, mixed with wheat seed in a liquid suspension of stickum material, can protect wheat from take-all without harming wheat yields.

The normal niche for pseudomonads in nature is in soil organic matter or on plant roots rich in nutrients. Lesions on roots infected with take-all leak nutrients that serve as food for the pseudomonads. The researchers speculate that the bacteria establish and multiply in these lesions and release antibiotics as a defense mechanism. Sensitive to these antibiotics, the take-all fungus ceases to grow at its usual pace and the development of the disease is suppressed.

"Take-all-suppressive soils"—as Cook terms the phenomenon—develop naturally in fields where only wheat is grown. After an initial 2 to 3 years of severe take-all in such fields, a qualitative change in the soil occurs that includes a higher frequency of antibiotic-producing pseudomonads. By 4 to 6 years, the soil is nearly "immune" to development of the disease. The exact role of the pseudomonads in natural suppression is not known but is under investigation.

"However," says Cook, "once a natural take-all-suppressive soil is achieved, crop rotation or fumigation must be avoided or the suppressiveness is lost."

The problems with natural buildup of take-all suppressiveness are that few growers can afford to sustain the losses required for the disease to run its course and that crop rotation is needed in many wheat-growing areas to control other diseases, weeds, and also erosion.

Treating wheat seed with pseudomonads before planting should provide take-all suppression much sooner than occurs naturally. Says Cook, "The first wheat crop after rotation to potatoes, alfalfa, oats, beans, or other crops not susceptible to take-all, is almost always free of take-all since rotation helps free the soil of the fungus.

"Suppression is needed for the second and third crops when soils are still take-all conducive and reinfestations can be rapid."

Weller says that the new treatment could be effective on virgin land, enabling growers to get good crops without having to endure the usual take-all problem.

"We've shown that this treatment has potential," says Cook, "but it's like the early wheat breeders back at the turn of the century when they developed the first winter wheats. Those first wheats were a major breakthrough but were only the beginning.

"We think the bacterial strains of pseudomonads that we've been working with are only prototypes of better strains still to be found or developed. Hopefully, selection and development of improved bacteria strains will not take as long as developing new wheats."

Currently, Cook and Weller are testing their treatment in commercial-sized plots and will have their results in late spring. They are also developing a mass screening program for selecting the better pseudomonads.

Cook believes that in the future, wheat breeders may need to combine varietal development with bacterization for effective disease control.

R. James Cook and David Weller are located at the Northwest Cereal Disease Laboratory, Johnson Hall, Washington State University, Pullman, WA 99164.—(By Lynn Yarris, Oakland, Calif.) ■

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Agrisearch Notes

SPAW Model Predicts Crop Stress

National, regional, or local soil moisture profiles and the resulting crop yields can be predicted with reasonable accuracy using a mathematical model called SPAW (Soil-Plant-Air-Water).

With general data that are readily available, SPAW can be used anywhere to predict daily, weekly, monthly or even yearly soil moisture and crop yield. SPAW was 10 years in the making. It is the creation of ARS hydrologist Keith E. Saxton, Pullman, Wash.

Food production depends on the availability to crop plants of water in the soil and on the ability of a given crop to withstand water stress. As pressure on the food production system expands, the ability to accurately and routinely predict crop yields and ferret out potential trouble spots where corrective action might be taken becomes increasingly crucial.

SPAW contains three components: climatic variables, including precipitation and evapotranspiration; crop characteristics, including growth and rooting; and soil characteristics, including the capacity to hold infiltrated water. Data on these components are fed into a computer along with a series of equations to provide predictions of soil water and crop water stress as well as crop growth and yield.

Though SPAW is a highly sophisticated and complex model, Saxton calls it "user-oriented." Growers will eventually be able to use it to predict the status of their soil moisture at any given time for decisions, such as choosing what crops to grow based on how much water is available in the soil at planting. They may also use it to help schedule irrigation. Hydrologists will be able to incorporate it into their own models to refine runoff prediction capabilities.

SPAW is more accurate than any of its predecessors. Also, current estimates of crop yield from a given area are made after the crop is in, whereas SPAW can predict yield throughout the growing season.

Saxton most recently has been using SPAW to predict the effects of drought and water stress on crop yields. He plans to continue testing the model in a wider variety of situations and applications.

Keith E. Saxton is located at Johnson Hall, Washington State University, Pullman, WA 99164.—(By Lynn Yarris, Oakland, Calif.) ■

Storing Those Fragile Lettuce Seeds

The best way to store lettuce seeds is to dry them to less than 7 percent moisture, seal them in moisture-proof containers that exclude oxygen, and then freeze them at 10°F.

Lettuce seeds are one of the most difficult of all U.S. agricultural crop seeds to store using conventional techniques. Special care, more than mere storage in temperature- and humidity-controlled rooms, must be used to ensure successful germination after storage.

"Just drying lettuce seeds to less than 7 percent moisture and sealing them in moisture-proof metal cans extends storage time up to 3 years compared to 2 years for seeds stored in paper bags at room temperature," says ARS plant physiologist Louis N. Bass, Fort Collins, Colo.

Lettuce seeds frozen at 30°F in sealed cans still germinated after 8 years. Dropping the temperature to 10° extended storage to 20 years.

Bass cooperated with Colorado State University graduate student Lindy Seip and ARS plant physiologist Eric E. Roos in the study.

Louis N. Bass is director of the National Seed Storage Laboratory, Colorado State University, Fort Collins, CO 80523.—(By Dennis Senft, Oakland, Calif.) ■